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INTER-OCEANIC CANAL PROJECTS.*

DISCUSSIONS

By ASHBEL WELCH and JULIUS W. ADAMS.

Discussion by ASHBEL WELCH.

As Mr. Menocal has invited criticism of his paper, I shall give it freely, without any regard to what project it may make for or against. I do not propose to discuss the general subject outside of the paper, nor to go much off the Nicaragua route.

I shall not express any opinion as to the proper route for the inter-oceanic canal, for I have not sufficient data for forming an opinion; and I am not quite sure that anybody else has.

My conception of the province of this "Society of Civil Engineers"

* Inter-Oceanic Canal Projects, by A. G. Menocal. Vol. VIII. p. 311 (November, 1879). Discussions on the subject. Vol. IX. p. 1 (January, 1880).

is, to arrive at and disseminate, correct *engineering* conclusions from data laid before us. To make these conclusions of any value, they must be free, impartial, and cautiously drawn. They can then be applied wherever they are needed as guides. It is our duty to give such opinions to the public.

To attempt to decide other than engineering questions, would weaken the influence and impair the usefulness of this Society.

Canal making has been for many years one of the lost arts. While much of the whole engineering ability of the world has been directed to improvement in railroads, improvement in canals has been thought of but by few. Old forms and rules, and ideas and precedents, founded on experience under circumstances entirely different from ours, make up the little that is said in engineering books on the subject. To make a canal requires much more skill and care than to make a railroad.

The plan before us contemplates a water communication between the oceans of 181 miles in length, of which, in round numbers, one-third is through Lake Nicaragua, one-third from the outlet of the lake down the San Juan river, formed into a succession of small lakes by dams, and the rest by canals connecting all these lakes with each other and with the two oceans.

As far as I can judge from the data given, the locations and general plans are highly judicious ; especially diverting the turbid waters of the San Carlos, an affluent of the San Juan, away from the line of navigation, and leaving the valley of the San Juan, and carrying the canal across the country to a harbor remote from the mouth of any very large silt-bearing stream.

I am glad that I am able to say so much in favor of the general plan and route, because on so many points I am compelled to differ from Mr. Menocal, in some very widely.

It is proposed to make the canal 72 feet wide at bottom, 26 feet deep, with slopes of 1½ to 1, and with locks, 400 feet long between gates, and 70 feet wide.

This depth would not, considering bars and irregularities always liable to occur, safely and practically allow sharp vessels of much over 24 feet draft to navigate it, nor vessels with but little dead rise with as much as 24 feet. The demands of ocean navigation are already requiring vessels of 26 feet draft, and this canal ought to be 28 feet deep.

In addition to this, the bottom, where practicable, should be dished

so as to be 2 feet deeper at the centre. This costs but little, and not only gives more room for the counterflow of the water around the vessel and under its bottom, just where room is wanted, but as a vessel always inclines towards the deepest water, it keeps her in the middle of the canal.

When the bottom is soft the rush of water under a vessel from the stem and keel, each way sideways, carries the mud from the centre of the canal, and piles it up along the angles of the bottom and sides. The dirt thus formed shows what nature requires.

The width proposed, 72 feet, barely allows two vessels of 42 feet beam and 24 feet draft to pass each other, and then only at great risk of scraping off their copper, or their rust preventing paint.

The slopes in earth are proposed to be 1½ to 1. In most cases that I know of, this has been found too steep, if the canal is much used; unless its banks are walled or paved. It is not safe to calculate for less than 2 to 1 below top water line.

The navigation of this canal will be largely by steamers. They wear down the banks, not because they go by steam, but because they go so fast. Their immersed midship section may be one-third of that of the water prism of the canal. Then the average counterflow of the water has half the velocity of the vessel, but under its bottom much more.

I have found that a boat of only one-fifth of the section of the canal, towed by a locomotive six or seven miles an hour, made sufficient commotion in the water to wear down the banks very rapidly.

The minimum curvature in the canal proposed by the Paris Congress, a mile radius, is unnecesarily large, if it is to be attained only at great cost. On the Raritan river, while passenger steamboats ran, they used to go around bends of radius not over four times their length, with three or four times the speed that vessels will go on this canal.

In a curve, the canal should be widened to an extent equal to the versed sine of the arc cut off by the length of the longest vessel.

Where it costs no more, the canal should have extra width and depth.

Scouring sluices should be made in the canals on the San Juan, where silt-bearing water comes into it. I have found such of very great advantage.

In rock cuts it is proposed to commence at the bottom with slopes of 1½ to 1, and carry it up nearly half the depth of the canal, then perhaps ½ to 1, to top water. This narrows the canal at bottom to sixty feet, con-

tracts the water space just where it is wanted, and makes it almost certain that the bilge of every passing vessel will strike the rock. The rock below top water should be cut down as steep as possible. The cost is small in comparison with the whole cost of the cut, in deep cut increasing it only five or six per cent.; while the advantage over the form proposed is immense. It is difficult to believe that the section shown is not a mistake of the engraver.

G. W. Pearsons.—An experience of several years' handling of vessels passing the Welland and St. Lawrence canals, shows that any bottom of rock that can possibly touch the bilges of vessels, is not only damaging but destructive, and that no vessel can touch any rock surface with any portion of the submerged hull and pass out of the canal with assurance of safety.

Ashbel Welch.—It is proposed to make the lock chambers 400 feet long. Steamers of more than that length are now in use, and the tendency is to make them longer. For such long voyages as will be made by ships passing through this canal large ships are most advantageous.

If it is worth while to make an inter-oceanic canal at all, it is worth while to make it big enough to answer the purpose. If the canal is ever made, the locks will probably have 500 feet length of chamber; and it is better to calculate for that at once.

This paper and the Paris Congress seem to assume that the locks of the same series should all have the same lift. In this case that is quite unimportant.

In most cases locks have been built where it is an object to save water, and so the same lockfull that passes a boat through one lock, is just sufficient, if the locks are alike, to pass it through the next, and so on through all. If unequal, the difference between one lockfull and another is commonly wasted. And so an inexorable rule seems to have been adopted, that locks connecting successive levels must always have the same lift.

In this case there is an abundance of water to use and to waste; and all that may be wasted by inequality of lift, can be passed down the canal without inconvenient increase of current.

Another consideration which led to this rule of uniform lift, was to secure uniformity in time of passage, so as to avoid accumulation of boats at the deepest and therefore slowest locks.

This is a controlling consideration where the locks are like those I

once saw on the canal along the Meuse, above Liege. The lock was filled by one small wicket; and my recollection is, that it took a full quarter of an hour to fill it. The locks I am most familiar with, perhaps four times as large as that, are filled in two minutes.

To fill a lock of 20-feet lift takes less than 50 per cent. longer than to fill one of 10-feet lift, and it can be done as safely, provided proper arrangements are made to secure the vessel. A lock of 20-feet lift would not cost over 50 per cent. more than one of 10-feet lift. The time lost by a vessel in passing a lock of 20-feet lift, would be but little more than half as much as that lost in passing two locks of 10-feet lift. It is not the filling and emptying, but getting in and out, that uses up the time, and that is the same in one lock as in the other.

I would put in locks of 20-feet lift on this canal, or even more, in all cases where the ground would admit of it.

It is proper that I should fortify my position by facts within my own knowledge. I once built a lock 220 feet long at Chesapeake City, on the inland water route between New York and Baltimore, of 16-feet lift. As the water had to be pumped up from the river below, I made a water-saving basin along side of it, eight times the area of the lock. It has been in successful operation for more than a quarter of a century, the basin saving nearly half the water. I was most unmercifully laughed at by a learned and able engineer who lived near the place (the same who laid out the rectangular part of the City of New York) for making a water-saving basin, a contrivance that had long before been exploded in Europe, and never used in this country. But, though violating an accepted rule, it succeeded; and has ever since saved several thousand dollars a year.

The reason why the contrivance failed in Europe was, that the basins, and the openings into them, were not big enough.

Many things given up as failures in one age or country become successes in another, by different circumstances, by improvement in subsidiary arts, or by avoiding former mistakes.

My old friend, Edwin A. Douglas, built locks on the Lehigh, of 30-feet lift, which worked safely and rapidly. His locks of 27½-feet lift were emptied in 1½ minutes,

The feeling against locks has grown up where water was scarce, where, for want of proper appliances, it took a long time to operate

them, and where the handling of large vessels by hand or by animal power was slow and subject to accident.

To overcome this slowness and risk, I for many years had in contemplation the working of locks and handling the passing vessels by steam. I carried it out ten years ago on the Delaware and Raritan Canal. It increases the capacity of that canal fifty per cent., and accidents, previously not infrequent, are not now heard of.

I was surprised afterwards, on visiting Europe, not to find any such contrivance for handling heavy vessels at the docks, though in many cases they had hydraulic power at hand. I am told that they have since used it. It should by all means be adopted in this case.

The intense preference for an inter-oceanic canal without locks, at the sacrifice of every other consideration, is a traditional *sentiment*, not an *opinion* founded on reason and calculation in view of things as they now are. It would be as reasonable to insist on a railroad absolutely without curves. Where there is plenty of water, as in this case, locks are comparatively small objections, unless there are too many of them.

The precedent of the Suez Canal should have little influence here. There there was no water to feed locks, no soil that would hold the water if they had it, and no drainage into the canal. On the American Isthmus the circumstances are just the reverse.

Several details of the locks, as shown by the plans in Mr. Menocal's report, I should make very different. For example, the angles between the bottom and sides are rounded and filled in. This is dangerous to deep vessels with sharp bilge, and takes away water space just where it is important for easy movement of the vessel, and that without any expenditure of water. On the Erie Canal they filled up the angles, but at great cost they cut them out afterwards.

I would use timber foundations, after the American fashion, because cheaper and safer, especially in a country where earthquakes are liable to crack concrete.

The hollow quoins should be of timber, which I have found not only to be cheaper, but more easily repaired, and enabling the gate to move with much less friction than against stone or iron.

The locks should be faced with timber, the most elastic that can be got, in this case 6 inches thick. It is not only cheapest, but it costs less to maintain it than ordinary cut stone faces. And it is of great advantage in saving the vessels from injury. In old times when packet boats

carried passengers between Philadelphia and Pittsburgh, I was told that those running west of the mountain, where the locks had cut stone faces, lasted five years; east of the mountain, where they had wooden faces, eight years.

Mr. Menocal expects to fill his lock, $400' \times 70' \times 13'$ lift, in six minutes, through two pipes 5 feet in diameter, with an aggregate area of not quite 40 square feet. To fill such a lock through such pipes, if the head of 13 feet was constantly kept up, and there was no friction or resistance, would require nearly five and a-quarter minutes. But as the head is constantly decreasing, and a large allowance for friction and obstruction from turning right angles must be made, the real time would be eleven or twelve minutes.

The pipes should be 8 feet in diameter, so as to have an aggregate area of full 100 square feet, and allow the filling to continue rapid after the head is reduced. The area of the water prism should be enlarged above and below the lock, and should be maintained quite to the lock, so as to enable the vessels to move with the least possible resistance. The guides into the locks should here be floats, not wharves. And the filling and emptying pipes should debouch, not on or near the face of the lock as in Menocal's plan, but as far to one side as possible, so as to make the least possible commotion in the water where the vessels lie. The locks should be operated and the vessels handled and held safely by steam, not on the vessel but on land.

The locks are estimated to cost about $35 000 per foot lift. Add for 100 feet increased length of chamber, and 2 feet increased depth of water, and larger feed pipes, and for a heavy expense in pumping, sure to occur, but not allowed or sufficiently allowed for, $15 000, making $50 000 per foot lift. Probably, with good grouted rubble masonry, or perhaps concrete, it can be done for that, but not with fancy masonry.

Mr. Menocal supposes a vessel can be moved into or out of a lock in a minute and a half. Judging from my experience in moving heavy boats, I should say it would take six minutes safely to pull one in with steam, overcome the inertia, and secure it, and four minutes to overcome the inertia and pull it out with steam. The gates ought to be worked by steam in two or three minutes (one and a half each), and the lock should be filled or emptied in five minutes. Other delays are sure to occur, especially on entering the lock when other vessels are about passing. The time lost for each lock, including slowing up on approach-

ing the lock and getting way on leaving it, will probably average half an hour.

The dams proposed are sufficient to pass the maximum flow of water from the lake, but not to pass in addition the water that accumulates in the basin of the San Juan, between the lake and the mouth of the San Carlos. Judging from the map, this may contain 1 500 square miles. The rainfall in a single storm may possibly be a foot, as I have known it to be (within narrow limits) in this country. In such works as this, the most extreme case must be provided for. The dams should, when possible, extend from rock to rock.

The strategy of floods is, not to attack them in front, but to flank them. Mr. Menocal has marked his abutment walls, and banks from them to the highland, only 10 feet above the crest of the dam. With such drainage and such rains, the discharge may, in extraordinary cases, be 400 000 cubic feet per second, and then the water would rise about 18 feet over the crest of a dam 1 000 feet long. Then, with the guard banks only 10 feet high, the flood would sweep them away, and the most disastrous effects would follow. The dams should be in wide places.

On the slackwater navigation of the upper Lehigh the guard banks between the ends of the dams and the mountain sides were raised some 10 or 12 feet above the crests of the dams. Then, with a smaller area drained in proportion to the length of the dams, a flood came in 1862, swept away those banks, and the whole navigation was utterly ruined.

It may be a question whether timber crib dams should not be adopted, instead of stone or concrete. I know any European engineer would turn away with disgust from such a proposition. Col. Adams, last Wednesday evening, made or quoted the just remark, that the engineering of each country should be according to its own "genius" and resources. Now, the "genius" of Great Britain is for iron, of France for concrete, of America for timber. The dams on the upper Lehigh were of timber cribs, and when the floods swept everything else away, banks and walls and rocks of many tons weight, these wooden dams stood alone in the midst of the torrent uninjured.

Such dams, when always kept wet, as they can in this case from the steady flow of the lake, will last a long time, perhaps a century, and then only the upper part will require repair. Every dollar saved will (money being seven per cent., compounded every six months) become

almost $1 000 saved at the end of a century. So it is better to expend $900 then, than one dollar now.

The equalizing effect of the lake on the flow of the water, and its purifying effect, and the use of it to stop the flow of water during construction, are of immense advantage to the safety and economy of construction of the works on the San Juan, and a powerful argument in favor of that route.

Disregard of the "genius" and resources and methods of our own country, and following European precedents established under circumstances entirely different, account for the fact that some of our best-read engineers were in former times least successful.

In the slack-water pools and in the lake where not already deep enough, Mr. Menocal proposes to cut channels with slopes of 6 to 1. If the material will stand, it is better to have the slopes steeper; a vessel coming against so flat a slope will stick fast—if steep, it will glance off.

Instead of so much excavation in the pools, making a rather imperfect and precarious navigation, it would be cheaper and better to raise the dams higher, or make the mouths of the canals lower down. Dredged channels fill up. The same cause that made the shoal is likely to make it there again. Jetties often only shift the difficulty to another place.

As Lake Nicaragua is too shallow for navigation, next its outlet, at the southeast end, it is proposed to raise the water 3 or 4 feet, and cut a channel several miles long in the bottom of the lake, so as to give 26 feet depth of water.

This depth is insufficient, even if the canal is no deeper. The depth would be diminished by a southeast wind, and without a considerable average depth under the keel a vessel would bump the bottom as she pitches or falls into the trough of the sea, the waves here, it is said, being almost like those of the ocean. The width of channel proposed by the Paris Congress is none too great.

The excavation for that width would, I infer from the data given, be somewhere about 10 000 000 cubic yards under water. Taking the chances of rock, it cannot be estimated to cost less than nearly as many millions of dollars.

Mr. Menocal, with apparent hesitation, suggested to the Paris Congress that the lake might be raised 3 feet more.

I should say, confidently, that the surface of the lake should be raised twelve or fifteen feet more. The excavation under water would then be

reduced to a few hundred thousand yards, and that near shore, with a saving, perhaps, of $8 000 000. It is a great deal easier to raise the top of a lake than it is to sink its bottom, if you have water enough, as you have here. I judge from the profile that the saving in the cut through the back bone of the continent—8 miles in length—would be about $2 000 000. This makes the saving by raising the lake 15 feet, $10 000 000. The annual interest on this, at 7 per cent. (and that is quite as low as you can expect to get money for this project), is $700 000.

On the other hand, you have 30 feet more of lockage, 15 feet on each side of the lake; which, at $50 000 per foot, will cost $1 500 000. The additional height of dam and guard banks may cost half a million; making in all $2 000 000.

This at 7 per cent. is	$140 000
Maintenance and attendance of locks due to additional height, say	30 000
Detention of 4 000 vessels, one hour each, at $15 per hour	60 000
	$230 000

This from $700 000 leaves $470 000 net annual saving; equal to a capital of about $6 700 000.

Of course these figures only express probabilities, but they are sufficient to call for a careful examination by some one possessing full and accurate information.

The only question is, whether much damage would be done by raising the lake so much. Judging from maps and the accounts we have, the damage would not be much. Suppose 300 square miles of land flooded, at half a dollar an acre, that would amount to only $96 000.

But this immediate saving by raising the lake is not the most important reason for raising it. The channel in the lake will fill up. Mr. Menocal finds much mud in the bottom of the lake. The same causes that put it and spread it there, will spread it there again. The piling up of the water by the trade winds, on the western shore, and its frequent reflux (which at one time led to the belief that there were tides on the lake), must cause currents along the bottom across the lake, and so tend to fill up the channel with mud.

But beyond even this, it is all important that vessels should have the whole open lake to sail in. In storms that are said to raise waves like those of the ocean, it would be very difficult to keep in a narrow channel.

A sailing vessel caught by a head wind in such a channel could not beat, and would be very likely to get aground.

Where a channel is unavoidable, the middle should be deepest, so as to give vessels a tendency to keep in the middle.

Mr. Menocal's estimate of the time required to pass through the canal is 38½ hours. That may be done with light steamers. Very heavy vessels will probably require twice as long.

Mr. Menocal makes the very incautious remark, that he sees no reason why the speed on the lake and river should not be as great as on the ocean. A North River pilot finds a great difference in his speed, whether he has 10 feet or 50 feet under his bottom.

Mr. Menocal estimates the cost of this work at a little over fifty millions. With the data before us, no man can tell what it will cost; but it is certain that it will cost much more than this estimate.

Few engineers in this generation would estimate canal work high enough. Items of the same name cost much more in canal than in railroad work. The movement is greater by human or animal power, the materials must be sorted more carefully, temporary railroads are not so readily used, and commonly the situation is lower and consequently the work much wetter. "Pumping and bailing" is always a heavy item, often a fearful one.

Mr. Menocal estimates rock at from $1.25 to $1.50 per cubic yard, it being, as far as we know, mostly granite and trap. If it were in a railroad hill-side cut, where after being blasted it could be moved a few feet and tumbled down the side hill, this might be a good big price. As it is on this canal, where much of it must be raised from 30 to 160 feet and then carried off quite a distance to get room and piled, and this done only with expensive machinery, requiring to be often and expensively moved, and as this trap-rock may be almost as hard as pig-iron, I should add at least a dollar a yard; making an addition of $15 000 000 to the estimate.

The earth excavation is estimated at 35 cents. On account of the same expensive hauling and carrying off and piling up as the rock, and as much of it will be wet, I would add 25 cents per yard to this, making an increase in the estimate of $8 000 000.

Embankment is estimated at 10 cents. Considering that to hold water under 26 to 30 feet head, only carefully selected water-tight earth will answer, and that carefully put in, in layers not over 2 feet thick (not any

kind of material tumbled down a high breast from a temporary railroad as in making a railroad bank), and as the banks are too narrow for such a head, I should add 25 cents per yard to this item; adding nearly $2 000 000 to the estimate, and this allows nothing for puddling.

The locks overcoming 212 feet are estimated at about $7 000 000. For the size and plan I think this is a fair estimate. But I would increase the amount of lockage to 242 feet, and the cost to $50 000 per foot lift, making the whole $12 100 000. . From this deduct the saving out of the estimate (not the saving as I should estimate) by raising the lake, say $4 600 000, and we have $8 000 000. So taking the balance between these, the estimate is increased $1 000 000.

To do the work in any reasonable time, 100 large steam pumps will probably be required, and must be kept in operation for years, many of them night and day. I should add at least a million to the estimate for this item.

These additions bring the estimate up to nearly $80 000 000.

As I never heard of a canal estimate that came anywhere near the cost, and considering the unhealthiness of the climate (the workmen there will not have Capt. Lull with the whole power of the government to enforce total abstinence), the necessity of importing labor, provisions, tools and some of the materials from a long distance, heavy storms and consequent interruptions, probable quicksands in earth cuts, probable hardpan or cemented gravel, &c., probable damage by floods while the work is unfinished and unprotected, the necessity for a large amount of protection walls, slope walls and paving which the estimate seems entirely to overlook, the great loss on machinery and tools, and the dwellings for the hands, I should add at least 25 per cent. for unknown or unestimated items and contingencies, bringing the estimate up to a round $100 000 000.

If it is done by the government and gets into politics, add at least 50 per cent.

If it takes 5 years to finish the work, and $20 000 000 are paid over at the beginning of each year, the interest during construction (at 7 per cent., compounded every six months) will be twenty-three millions and a half; if $12 500 000 every 8 years, about 38 millions; if $10 000 000 every 10 years, nearly 49 millions.

This shows the propriety of getting thoroughly ready before beginning to spend large sums of money. The location should be definitely made, the ground and rocks, and the lake and river bottoms thoroughly

explored by pits and borings where necessary, the plans and specifications fully drawn out in detail and printed, the kind and amount of the necessary machinery ascertained, and the legislation and right of way settled, so as to have no delay when the work is once begun.

When the character of work is doubtful, reliable contractors will take it only at prices that will cover the risk. If it turns out easy they pocket the difference between the supposed and actual cost, but if it turns out worse, then not the contractor but the owners of the works will lose the difference. So those owners should remove all doubt.

The conclusions I have arrived at, and the estimates I have made, are mainly from the papers before us. Other and further information might change or modify many of them very much.

Great as is the undertaking to build the Nicaragua Canal, it is mere child's play, compared with the attempt to make a thorough cut through the valley of the Chagres, with its two and twenty rivers, which at times become so many deluges.

The opening of a canal across the great American Isthmus would be of great advantage to this country and to the world. Not only commerce would be benefited, but it would add another tendency towards the assimilation, the civilization and the christianization of mankind. But don't let us go into it without looking the risks and difficulties full in the face. Let us carefully and honestly count the cost. Let us take care not to allow those acting under our advice to place themselves in the predicament of the man who began to build, and was not able to finish.

Discussion by Julius W. Adams.

In response to the request of the officers of the Society, I have the honor to address you on the subject of the inter-oceanic transit of the American Isthmus.

Some ten years since I had occasion to read a paper before the Society, advocating the construction of a ship canal at the Isthmus of Tehuantepec, rather than at Panama, not on the score of its cheaper construction, but entirely in the interest of American commerce, pointing to the necessity of such canal debouching into the Mexican gulf, in the

interest of our domestic commerce, instead of its approaches being favorable to foreign commerce and domination by foreign guns, as would be the case if the transit were made at any other of the points which have been proposed than the Isthmus of Tehuantepec.

The subject was looked upon then as something far in the future, if indeed it had any merits as a practical problem, but it resulted in a resolution of the Society, of date March 16th, 1870, calling the attention of Congress to the need of a more thorough examination of the Tehuantepec Isthmus, and led, it is believed, to an appropriation by Congress to test by survey the practicability or non-practicability of constructing a ship canal at that Isthmus, and the survey was made under the orders of Commander Shufeldt, of the U. S. Navy, and Professor Fuertes, a member of this Society, was the chief Civil Engineer of the expedition. It resulted in a report that 172 800 000 cubic feet of water daily could be relied upon in the dryest season to feed the summit-level, and that no impediment whatever existed to the construction of a ship canal. The sufficency of this quantity of water to the wants of a ship canal, is shown very conclusively, and with proper detail, by Mr. Fuertes, in a manner which admits of no cavil, and that making all needful allowance, in accordance with experience elsewhere, for the loss by evaporation, filtration, and leakage, there remains an ample water supply for the lockage of a daily traffic, amounting to 20 000 tons, and he gives his opinion to the effect that the supply would furnish water to the extent daily, if need be, for a traffic of 30 000 tons. This sufficiency of water confirmed the statements made by Mr. Moro in 1844, as the result of his examination.

You are all sufficiently impressed with the importance of an inter-oceanic canal through the American Isthmus somewhere between North and South America, for the advancement of commerce, and folios have been written, from the time of Columbus to the present day, on the benefits to be anticipated from the completion of such an enterprise to the world at large, which, before this audience, need only be referred to, without wasting time upon a consideration of them, but there *is* a view of the question which is not quite so hackneyed, and which it well becomes the members of this Society to carefully consider before committing themselves to the support of either of the schemes which have occupied the press for some time past, and this is the *American*, as distinct from the European side of the question, and which has been very much

lost sight of in the glamour attending the proposed "grand monumental structure" of the age. It is to this *American* view of the needs of *American* commerce that I propose as briefly as possible to call your attention.

It will be perceived in reviewing the proceedings of the Paris Congress, so called, that the *foreign* idea centered upon Panama, as the proper point at which to construct an *international* canal (which expresses something more than a merely *inter-oceanic* transit), and if not an *international*, then an inter-oceanic as near as possible to the Isthmus of Darien, and for this M. Ferdinand de Lesseps is the head and front. A canal with locks is not monumental enough for his ambition however, and if a system of locks is finally agreed upon as necessary, his interest in the subject will be materially lessened, if it does not vanish entirely.

Such of you as have informed yourselves of the precise character of the obstructions encountered in the construction of the Suez Canal, need not be told that M. de Lesseps is a man of ability and energy; and he may be a very proper man to direct such an enterprise as the one before him, but if he be, it cannot be inferred from anything he has done at Suez. Everything connected with carrying out the scheme of a through cut at Panama is so totally and entirely at variance with his experience heretofore, that success in the first mentioned is no guarantee whatever that he has grasped the difficulties of the latter. His visit to Panama may, or it may not, open his eyes; in either event, however, the result will be the same. That is to say, we feel well assured that such a canal will never be built, for the simple reason that Asiatic-European commerce alone will not pay a return on the necessary investment, whilst American commerce can be more economically provided for by an American route, as will be seen.

While in the Congress at Paris, foreign opinion was largely in favor of the Panama route, yet sensible men were to be found among them to admit of the *possibility* that perhaps nature will forbid of a *commercially* successful ship canal being built and sustained across the "narrow lands" of the continent further south than the Nicaraguan Isthmus, in which case their assent can be had to that; but not a foreigner could be found among them to entertain the idea for a moment of the feasibility of the Tehuantepec canal! And why was this? All that had been accomplished in the examination of the Tehuantepec Isthmus was known to them. The President of the latter company had, in 1871, appointed a Commission of Engineers to visit the water-ways of Europe, and from an

examination of existing works report upon the merits of that line for a ship canal. He had applied to the American Government for the appointment of an Engineer to be attached to that commission, and Gen. J. G. Barnard, of the Corps of Engineers, U. S. A., had been detailed for that service, and visited Europe as one of the commission which subsequently reported upon the Tehuantepec ship canal project as without doubt the simplest and cheapest line yet suggested for such a purpose. This report, printed in October, 1871, was known to *some* of the members of the Congress, possibly to all.

The objection to the Tehuantepec line could not have arisen from the fact of lift-locks being required on that route, for the chief objection to locks (aside from the expense) is presumably in the loss of time which they would occasion in transit, and the Nicaragua route, with twenty-one locks, would admit of comparison with other lines having a greater number of locks, providing *that* circumstance was compensated for by other and superior advantages, the difference in the amount of lockage in the two cases, being measured by *hours* merely of increased time of transit. No; the objection to the more northerly route grows out of the fact that the Tehuantepec will be an *American* canal, first and foremost; and, while it might accordingly be of world-wide usefulness, its construction would give an undue preponderance to the rapidly-growing commercial supremacy of the Great Republic, and tend to nullify the present existing advantages possessed by the commercial nations of Europe, in competition with this country for the commerce of her *own* ports, as well as that legitimately hers by reason of her geographical position.

It is believed that evidence exists in the Department of State at Washington showing that the resident English Minister in Mexico actively and personally exerted himself with members of the Mexican Congress to procure the rejection of the Tehuantepec Treaty of 1851; and it is well known that the presumed antagonism in Mexico to the Americans of the North is not of native growth, but has its rise in the jealousy of resident German and English merchants.

And not a dollar could be had in England for the construction of a canal at Tehuantepec unless controlled exclusively by English capital and under her protectorate.

The geographical position of the United States calls for the construction of an *American* ship canal for the ameliorization of American com-

merce, and to strengthen the prestige which rightfully belongs to this country when it is the question to improve her own water-ways.

It is all very well to *talk* of the progress of mankind, and the more liberal policy which should obtain in the intercourse between nations, and to refer to the broader views of national reciprocity which should prevail in this enlightened age, but principles of philanthropy never will be permitted to control in matters of trade and commerce, and until the advent of the millenium, governments, while extending even-handed *justice* to all, will always rightfully aim to secure the material prosperity of their own people.

You have heard of the Monroe doctrine, as enunciated briefly, thus: "No more European settlements on this continent." To this we would add, what by fair inference it embraces: "No European partnership or co-protectorate in regard to *our* Isthmian ways and inter-oceanic communications." These ways, if necessarily opening into the Carribean Sea, are even then essential to a successful prosecution of our commerce with the South Seas. If they open into the Gulf of Mexico, they are domestic to ourselves. The desire of making the Gulf of Mexico a closed American sea is as natural to us as a similar policy to other powers in regard to the Black Sea, the Caspian, the Zuyder Zee, and others, and as Cuba is the key to the outlets of this sea, it becomes an inevitable destiny to acquire or to attain a Gibraltar on its shores in order that foreign fleets shall not interrupt our domestic commerce. The older governments of Europe affect to be startled at this enunciation of American policy, as though it were a new idea; but it is not. England openly avowed the principle, when she secured and held by the strong hand Gibraltar, Malta, and Aden in the Red Sea, and now Cyprus as on the route of her Indian trade. There is no more reason why foreign nations should be allowed to guarantee the neutrality of an American thoroughfare than that the United States should be a party to defend the British Channel, the Straits of Gibraltar, or the Isthmus of Suez.

In attempting to sketch the broad outlines which indicate the *where* of this American canal, I shall avail myself freely of the labor of others, and I am particularly indebted to a volume by Mr. Henry Stuckle, published in New York in 1870, for the tables of distances between ports, as well as for the views which he has so ably expressed in the advocacy of the line of transit, the merits of which I wish to press upon your attention.

Lieutenant Maury, in a letter written to a member of Congress some

twenty years ago on this subject says : "Owing to the course of winds, the direction of currents, and other physical circumstances, British merchants are ten days sail and upwards nearer than we are to all the markets of the world, except those of the Caribbean Sea and Gulf of Mexico. They are next door to all the markets of Europe, to Brazil, to Cape Horn, to the Cape of Good Hope ; and, consequently, to all ports beyond them, they are practically some ten or fifteen days' sail nearer than we are. A vessel from the United States, bound to the southern hemisphere, first sails nearly an east course until she arrives in the vicinity of the Azores and Canary Islands. She then puts her head south for the first time. Now, while the American vessel is sailing this route, the English vessel that sailed on the same day, for the same market, has passed those islands and is far on her way, for the reason that the Cape Verde Islands are some ten or fifteen days nearer to England than to America ; England is that much nearer to the southern hemisphere ; for vessels generally, whether from the United States or from England, are in the habit of passing by these islands in their way thither."

But it is not to meet the requirements of an European or an Asiatico-European commerce that a transit through the American Isthmus is to-day demanded (in times back it was otherwise), but, on the contrary, it is now mainly for *American commerce, in America*, and between American ports, and their commercial connections with the East, that such a canal is desirable, if not indispensable.

Our national territory has extended to the shores of the Pacific, and is now bounded on the south by the Gulf of California and the Rio Grande. Communication between our ports on the Atlantic and those of the Pacific requires protracted voyages. The distance from New York to San Francisco, for example, is over fourteen thousand nautical miles, by sea. The moment we are able to penetrate the Isthmus we have cleft America in twain, and we can pass from the north shores on the Atlantic to the corresponding coasts of the Pacific, without needing to descend to the fifty-fifth degree of south latitude. This will be the first great advantage, and the most important to the United States, which will be realized by the establishment of a water transit between the coasts, more available than any railway. There is here a great question, commercial, political, social, and economical, which is so clearly apparent as scarcely to require elucidation ; its statement alone sufficiently sets forth its importance.

In looking for the *where* we can best cross the continent, the point which first arrests our attention is the Isthmus of Tehuantepec, which is only 500 miles from our southern frontier at the Rio Grande, in Texas, and is accessible by means of the Gulf of Mexico, which is an inland sea, in a sense; and in the improvements of river navigation the shipping from our interior commercial centres will be able to extend their voyages to the coast, thus virtually emptying the Mississippi River into the Pacific Ocean.

If we examine the map it will be seen that this isthmus is the most feasible point at which an inter-oceanic communication can be had, whether we consider it especially in reference to the United States alone, or to the other American and European and Asiatic countries. From Europe or the United States to the Pacific it is the shortest route of any either now in operation or at present contemplated. This is exhibited in the following table, showing the respective distances from England, New York, and New Orleans to the port of San Francisco, in California, by the routes of Panama and Tehuantepec compared with the voyages from the same places round Cape Horn, and showing also the distance each would respectively save by traversing the American Isthmus:

Voyage to San Francisco, California	Round Cape Horn.	Via Panama.	Via Tehuantepec.	Dif. in favor Tehuantepec.
From.	Stat. Miles.	Stat. Miles.	Stat. Miles.	Stat. Miles.
England (Liverpool)	15 710	8 607	7 476	1 131
New York	16 360	6 218	4 741	1 477
New Orleans	16 500	5 718	3 384	2 334
Saved by		Distance saved via Panama.	Distance saved via Tehuantepec.	
England		7 103	8 234	1 131
New York		10 142	11 619	1 477
New Orleans		10 782	13 116	2 334

From "*The Tehuantepec Railway, its location, features, and advantages under the La Sere Grant*, 1869."

In order to complete the above table, so far as it concerns our trade

with California, we present a comparative detailed table of distance and time for voyages from New York and New Orleans to San Francisco by the two routes, according to the statements of distances (in statute miles) in the "*Memoir on Ocean Routes*," published in 1857, by Captain F. J. Cram.

The time required in each voyage, as indicated, including the delays rendered necessary by the discharge and reshipment of cargoes, is calculated from the average figures presented by the *log-books* of the steamers, connecting with the Isthmus of Panama, on the two oceans :

New York to Aspinwall	2 392	miles	in	8	days.
Aspinwall, by railroad to Panama	51	"	"	1	day.
Panama to San Francisco	3 775	"	"	13	days.
Total for the route of Panama	6 218	"	"	22	"
New York to the Coatzacoalcos	2 275	"	"	8	"
Railroad across the Isthmus	162	"	"	1	day.
Isthmus to San Francisco	2 304	"	"	8	days.
Total for the route of Tehuantepec	4 741	"	"	17	"
Difference in favor of Tehuantepec	1 477	"	"	5	"

By adopting for the trip from New York to the Coatzacoalcos the route of Fernandina (Florida), the distance becomes reduced from 2 275 miles in 8 days to 2 160 miles in 7 days (according to the tables of distances furnished by the Bureau of Navigation, in the Navy Department at Washington), as follows :

New York to Fernandina	969	miles	in	3½	days.
Fernandina, by railroad, to Cedar Keys	154	"	"	1	"
Cedar Keys to the Coatzacoalcos	1 037	"	"	2½	"
Total	2 160	"	"	7	"

It follows that, taking into account the saving obtained by the Fer-

nandina route, the difference in favor of Tehuantepec is increased from 1 477 miles and five days to 1 592 miles and six days.

The further south we go in the United States, the more clearly evident become the advantages of the Tehuantepec route. New Orleans is but 918 miles from the mouth of the Coatzacoalcos, and twelve days suffice for the voyage from New Orleans to San Francisco, as follows :

New Orleans to the Coatzacoalcos	918 miles	in 3 days.
Railroad across the Isthmus	162 "	" 1 day.
Isthmus to San Francisco	2 304 "	" 8 days.
Total	3 384 "	" 12 "
The same trip via Panama requires	5 718 "	" 22 "
Difference in favor of Tehuantepec	2 334 "	" 10 "

RESUME OF TIME OF VOYAGES BY THE TWO ROUTES.

	Via Panama.	Via Tehuantepec.	Difference in favor of Tehuantepec.
New York to San Francisco	22	17	5 days.
New York by Fernandina to San Francisce	—	16	6 "
New Orleans by Havana to San Francisco	22		
New Orleans to San Francisco		12	10 "

We have already seen that the geographical position of the Isthmus of Tehuantepec offers for the European trade with California, Japan and China an improvement of 1 131 miles.

The central part of our continent, which we call the Isthmus, extends from Tehauntepec to the main land of South America, with a length of about 1 500 miles.

If we imagine two canals, one at each extremity of this Isthmus, it is not strictly true that in making a voyage from a northeastern latitude to one corresponding in the northwest, and by taking the southern canal instead of the northern we should add twice the length of the Isthmus, or 3 000 miles to our voyage. Owing to the configuration of the land south of Cape Hatteras, and the location of the Antilles and their neighboring shoals, the navigator from the northeast—on the Atlantic side—compelled to approach the Isthmus in an oblique direction ; he does

not coast it from north to south. On the Pacific side the case is different; there, the sailor going from north to south, or from south to north, skirts the shores of Central America, and describes in his course a distance corresponding nearly to the length of the Isthmus. For these reasons, a difference of from 1 500 to 2 000 miles is all that is admitted in a voyage from New York to San Francisco in favor of the northern route. This difference, however, remains sufficiently formidable in a voyage of about 5 000 miles, supposing the existence of an inter-oceanic canal. For steam navigation the difference is naturally somewhat less.

In the table we have given, page 65, the difference in a voyage to San Francisco between the two routes of Panama and Tehuantepec, is estimated at 1 477 statute miles, from New York, and 1 131 from Europe, in favor of the latter. The distances are *estimated* for those portions of a route where no established steam lines exist. In the subject under discussion, however, the interests of the sailing marine have their full importance, as a great part of the commerce between the Atlantic and Pacific States, by reason of the nature of their cargoes, will be carried on in preference by sailing vessels. The difference in the distance to be run by the one route or the other has thus to be taken into account at its full value.

It may be stated approximately, that whatever route through the American Isthmus should be opened, it would at once command the trade between Europe and California, and our own trade with the west coast of America, west coast of Mexico, and the Pacific States. This is estimated at 1 500 000 tons, one-half of which is between the northwest and northeast of our continent, and one-fifth between the northwest of Europe and the northwest of America. Should we propose to impose upon two-thirds of our whole commercial movement above noted, an unnecessary detour of 1 500 miles by forcing it to cross at the southern rather than at the northern end of the Isthmus? Certainly no one would have the courage to advocate such a proposition, and yet the location of a ship canal at Panama aims to bring about precisely this most singular achievement.

In examining the above statement two leading ideas develop themselves. The first is, that the American canal (Tehuantepec) is destined to serve especially the commercial interests of America. Two-thirds of the commerce which is interested in the construction of this canal may be estimated as American.

The second point which becomes apparent is, that in providing first for the interest of American commerce in the location of the canal, those of all other parties are at the same time equally protected.

If we examine the position of this route with reference to the relations of our Atlantic ports and Europe with the western shore of South America, we find that Tehuantepec is over ten degrees to the north of Panama, and that freights leaving Tehuantepec for the south would be compelled to traverse the Pacific for the entire distance which separates Tehuantepec from Panama, in order to secure the same relative position as those transported via Panama. At first sight, this difference in the voyage to be made presents an apparent disadvantage, which has, nevertheless, no existence, for a very simple reason. Either the freights via Tehuantepec in this case, are bound from the Atlantic ports of the United States and from Europe for the western coast of South America, or they leave the ports of Peru and Chili for the Eastern United States and Europe. In the former case their Atlantic trip would be shortened by all the distance between Tehuantepec and Panama. It is, therefore, evident that they should run upon the Pacific the same additional distance as they would have run upon the Atlantic, in case they had been going by way of Panama. In the latter case the greater distance to be run on the Pacific in order to reach Tehuantepec, compared with the transit by Panama, is compensated by an equal distance saved on the Atlantic side. This refers, of course, to a movement from the northeast to the southwest, and the reverse.

The saving of time and money by the employment of a ship canal traversing our continent, with reference to the trade between our eastern and western shores, is almost beyond calculation, by reason of the geographical position of the Atlantic and Pacific States. The distance of 16 360 miles from New York to San Francisco, by way of the Cape, for example, will be reduced to 4 740 by canal, which, for the present, we suppose to be located at Tehuantepec. The voyage will, therefore, be reduced by 11 619 miles, and the duration 105 days—the sailing vessel requiring, say 150 days by the Cape and 45 days by the canal.

According to the estimated cost of a voyage to San Francisco the reduction in the duration of the voyage will secure an economy of $9 261 for a vessel with a crew of thirty men, and another saving of $4 042 in insurance and in interest on the capital presumed to be represented by the cargo. And the total saving for a single trip would be $13 300, which,

with reference to the tonnage, supposing the ship to be of 1 000 tons, would make a saving of $13 per ton, or $26 per ton for the round trip going and returning. Such an improvement in the conditions affecting our commercial relations with California when the inter-oceanic canal is opened, would cause a revolution in the supply of food and other domestic products to our great centres of population on the Atlantic coast.

This improvement would bring our manufactures and commercial centres in the Eastern States nearer to our Pacific possessions, with their increasing population, by distances measured by thousands of miles. And on the other hand, from San Francisco to Liverpool, the ship laden with our produce is now compelled to make a voyage of 15 710 statute miles, which would be reduced to 7 476; yet, notwithstanding this necessity, the agricultural products of the rich soil of our Pacific States can now compete with similar products in the European markets. What will these shipments become when forty-five days instead of 150 days shall suffice to bring them to the shores of the Atlantic, and what a feature in the agricultural development of the Pacific States will this shortened voyage to Europe offer. From California to the eastern coast of South America, as for example, to Rio Janeiro, we have to traverse a distance of 9 200 miles, being always under the necessity of doubling the Cape, whilst by way of the Isthmus the products of the Pacific States destined for Brazil would be conveyed 4 500 miles.

Passing from our internal commerce, and from the consideration of our agricultural exports to the question of importation and exchange, which has as yet hardly made a beginning with the western coast of South America, we immediately perceive the bearing of a water transit across the Isthmus. The new route (Tehuantepec) will bring our eastern ports exceptionally near to those of western South America, the commerce of which is at the present time almost all absorbed in Europe. We have actually 8 700 nautical miles to traverse in going from our Atlantic ports to Valparaiso, and 9 900 nautical miles to Callao. New York will not be further from these ports than England when the passage through the Isthmus shall be opened, and the voyage from our commercial metropolis to these ports will be reduced nearly *one-half* for the first and *two-thirds* for the second. In fact, the western coast of South America will be brought so near to our Atlantic ports that we shall, in part at least, supplant Europe in their commerce.

The following table, furnished by the Navy Department at Washing-

ton, shows the comparative distances from Europe to Australia and eastern Asia by way of the Suez Canal, and a canal across the American Isthmus :

	Via Suez.	*Via* American Isthmus.	In favor of Suez. Naut. miles.
From Liverpool to—			
Hong Kong	9 568	14 220	4 652
Shanghai	10 368	13 820	3 452
Yokohama	11 403	12 900	1 497
Melbourne	11 269	12 600	1 331

We need not observe that the distances themselves are not to be accepted as a final argument in a discussion which involves navigation in general. However we may regard these distances as a base of argument in speaking of steam vessels, we are compelled to admit other weighty considerations when we come to deal with sailing vessels. We are well aware that the region in which the trade winds are most reliable, corresponds with the American Isthmus. The trade-wind region extends on either side of the equator, on the Atlantic and Pacific, to the parallels of 30° north and 30° south latitude. The facility of availing of the trade winds by employing the American canal for sailing vessels between Asia and Europe, may doubtless attract a part of that trade to the American Isthmus ; but in view of the change which is taking place in the construction of sailing vessels, the tendency to substitute steam for sails in long voyages, and the special facilities offered by the Suez route for steam navigation, the utility of the American canal to the Asiatico-European trade must continue still problematical.

We give the following table of distances from New York to the two prominent ports of the western shore of South America, by way of the Cape, and by way of an inter-oceanic canal :

Ports.	By way of Cape Horn.	By way of an Isthmian Canal.	In favor of the inter-oceanic Canal. Naut. miles.
Valparaiso	8 720	5 000	3 720
Callao	9 920	3 700	6 220

This reduction would give us a marked advantage in competition with the maritime countries of Europe.

To render still more striking the effect of the location of the inter-oceanic canal at one point rather than the other, let us compare the results which would be attained by the two rival routes. For this purpose we give here tabular statements, prepared in the Hydrographic Office of the Bureau of Navigation, indicating the distances from New York and New Orleans to the principal ports concerned by way of a canal at Darien and of one at Tehuantepec. These tables give at the same time the distances *via* Cape Horn.

TABLE OF DISTANCES FROM NEW YORK.*

To	*Via* Cape Horn.	*Via* Isthmus of Darien.	*Via* Isthmus of Tehauntepec.	In favor of the Canal at Tehuantepec. Naut. miles.
San Francisco	14 200	5 300	4 400	900
Mazatlan	13 000	4 060	3 135	925
Melbourne	12 720	9 890	9 600	290
Honolulu	14 100	6 730	5 955	775
Yokohama	17 340	10 210	9 435	775
Shanghai	18 300	11 100	10 355	745
Hong Kong	19 000	11 500	10 755	745

TABLE OF DISTANCES FROM NEW ORLEANS.*

To	*Via* Cape Horn.	*Via* Isthmus of Darien.	*Via* Isthmus of Tehuantepec.	In favor of the Canal at Tehuantepec. Naut. miles.
San Francisco	14 500	4 650	3 070	1 580
Mazatlan	13 300	3 390	1 800	1 590
Melbourne	13 000	9 250	8 260	990
Honolulu	14 400	6 030	4 620	1 410
Yokohama	17 600	9 510	8 100	1 410
Shanghai	22 300	10 430	9 020	1 410
Hong Kong	19 300	10 830	9 400	1 430

* "In general the distances are measured on steam routes, when lines are established, and are approximately correct."—Observation by the Hydrographic Office to its tables.

We give now the respective distances from the Lizard to the prominent ports of eastern Asia by way of a canal at Darien and of one at Tehuantepec.

DISTANCES FROM LIVERPOOL TO EAST ASIA.

To	*Via* Isthmus of Darien.	*Via* Isthmus of Tehuantepec.	In favor of the Canal at Tehuantepec. Nant. miles.
Yokohama	12 900	12 400	500
Shanghai	13 820	13 320	500
Hong Kong	14 220	13 720	500

The Asiatico-European traffic through the American canal would certainly be inferior in amount to the trade which is directly interested in the construction of the proposed transit, and to whose especial convenience the canal should be adapted. In case the selection made of the location of the canal should not answer completely the requirements of foreign commerce, we could not hesitate on that account, as our own interests must first of all be protected; but when it is shown that the northern location gives not only an advantage to American commerce, but something to that of Europe also, we can but be the more strongly confirmed in our choice.

In commerce, all questions become affairs of arithmetic and figures. Without attempting in any case to make too elaborate an argument, let us calculate the loss to American commerce which would be caused by the adoption of the Darien route. We see by the calculation made of the expenses of a ship of a thousand tons, from New York to San Francisco, by way of the Cape and by way of the canal, that the latter are estimated at $6 843 for ship and cargo. If, in consequence of a detour occasioned by the location at Darien, this voyage of about 5 000 miles should be increased by 1 500, the cost of transportation, which is nearly in exact proportion to the duration of the voyage, would be augmented by at least one-fourth, say $1 710. This is for the commerce between New York and San Francisco, estimating it at only 500 000 tons, and if we represent this movement by five hundred vessels, averaging one thousand tons each, we find that the annual augmentation in the cost of

transportation would be $855 000, on account of the unnecessary detour. Estimating the shipping between California and Europe at only 200 000 tons, we have seen that for the trade of Europe with California the detour occasioned by a canal on the southern part of the Isthmus, is at least 1 000 miles. We therefore represent the cost of the detour to this branch of trade as one-fifth of the $6 843 mentioned above for the cost of a voyage of a sailing vessel over five thousand miles, say $1 368, and allowing for the given commercial movement of 200 000 tons, two hundred ships of one thousand tons average, we see that the increase of expenses would be $273 600. Adding this to the $855 000, we have the sum of $1 128 600 for the loss which the location of a canal in the southern part of the Isthmus would cause annually to our commerce. This is an under-estimate, without taking into account the loss to our Asiatic and other shipping, and the impossibility of bringing our Pacific fisheries as near as is desirable to their ports of outfit. So much for the times of peace.

But the entrance to the Caribbean Sea, which washes the shores of the southern isthmus, is commanded by English cannon. What would become of our access to our canal in time of war, located as it would be in a situation where its defense by us would be difficult, if not impossible? International wars may be expected to become more and more unfrequent, as commercial and industrial development establishes between the different peoples that community of material interests which is of itself the surest guaranty of peace; but provision must be made for a very different state of things; here again the extreme north of the Isthmus offers us special advantages. A canal terminating in the Gulf of Mexico would be very easily protected in time of war, and by making, in case of need, the Gulf a closed sea, our merchant marine would be secure from all attack, and our relations with the Pacific could be sustained without any interruption. This is a consideration which, in the eyes of our statesmen, ought to constitute an argument in favor of the more northerly locality.

I have thus very imperfectly sketched the great advantages, not to say the *necessity*, of withholding our assent as Americans from any project, however feasible it might appear, which looks to piercing the American Isthmus at Panama or Darien. I go further, and do not hesitate to declare my conviction that were there a strait now exisiting at Darien as

at Magellan, the necessities of American commerce would ultimately open a route through the Isthmus of Tehuantepec.

Look at the Peninsula of Florida—our government, not satisfied with the results of the survey under Gen. Bernard in 1829, have ordered a survey, under Gen. Gillmore, from Fernandina to Cedar Keys (150 miles). This, if opened for coasting trade, would pay in the reduced insurance growing out of the dangers of navigation through these seas in time of peace, and these dangers are even greater for sailing vessels further south, from the cyclones and hurricanes, which, as we approach the equator, are more frequent and violent than in higher latitudes, and add to the other impediments to safe navigation of the entrance of the Carribean Sea.

But so far from the strait being an existing fact, you are called upon to aid in making an artificial one, the obstacles to which the data in your possession tells you cannot be overcome save by an expenditure of life and money in its construction and maintenance out of all proportion to the comparatively limited amount of foreign commerce which would seek that channel. And the reliance for the support of the enterprise is looked for in the probability that American commerce would add its quota to its revenues, and its capital to its construction. In fact, without this latter it cannot be accomplished. Did no other attainable route offer, it is to be feared we might be seduced into lending our assistance to this, even to the ultimate injury to the *growth* of our commerce. We appeal to the patriotism of our people, and the statesmanship of our rulers, to prevent such a consummation. If foreign commerce can build and support such a movement, to their enterprise, and their hostility to American progress, it is questionable if we should look on without interference, but let us not ourselves commit hari-kari, to the manifest satisfaction of the enemies of our institutions.

It is a waste of words to discuss the bearings of the uncertainties as to the effect of deadly climate, tropical rains, absence of population, and materials for construction and supplies of all kinds, uncertainties as to geological features in their influence and cost, and character of material to be encountered, high and unheard of tunnels, aqueducts for the conveyance of angry rivers, earthquakes, infiltration, and undeveloped obstacles, to the successful construction and operation of rival projects —all hampered by the same difficulties, only in uncertain degree, and neither of which would our interests call upon us to accept at any price.

I allude to the various rival projects at Darien and Panama, the respective merits of which no longer interest us a practical problem, and we may dismiss them from consideration.

The conviction which is growing in the minds of intelligent men, as the facts open before them, is clearly that lifting locks are a *necessity* in any canal across the American Isthmus; if locks, it then becomes a question of *how many*, and at what cost, and in consequence, as the idea of a through cut fades away, we no longer consider millions of money a mere bagatelle, but look to the *cost* of a locked canal, and in consequence the Nicaraguan project has acquired an importance which a few years since it could scarcely have hoped to attain, and instead of fighting windmills at Panama, the field becomes really narrowed to a comparison of the respective merits of the Nicaragua and Tehuantepec ship canal projects with locks.

In a tabular comparison of distances we have shown the great preponderance which exists in favor of a transit by way of Tehuantepec rather than by Panama for American commerce, irrespective of engineering obstacles at either point, and for which I am indebted, as I have stated, to the researches of W. H. Stuckle, and which was undertaken by him before the route *via* Nicaragua had loomed up so prominently as now, and was scarcely regarded as a rival to the Tehuantepec. Time did not permit me a thorough reconstruction of those tables with sufficient accuracy to meet the new comparison now called for of Nicarauga with Tehuantepec, nor in view of an increased commercial tonnage, but a few notes will show the direction which this comparison would take.

The harbor of Greytown (San Juan) is in latitude 11° North, Panama being 7½°, while the mouth of Coatzacoalcos, on the Tehauntepec Isthmus in the Gulf of Mexico, is in latitude 18°. Panama, or rather Aspinwall, is 1 600 miles by steam from New Orleans, and Greytown, in Nicarauga, is 1 500 miles, while the Coatzacoalcos is 918 miles. The western port of the Nicaragua canal is 700 miles southeast of Tehuantepec, and nearly the same distance (640 miles) northwest of Panama; from New Orleans to Tehuantepec, on the Pacific coast, is $918 + 160 = 1\,078$ miles; from New Orleans to the same point *via* Nicaragua is $(1\,500 + 180 + 700)$ 2 380 miles, or more than twice as far; by way of Panama it is $(1\,600 + 1\,340 + 50)$ 2 990—say 3 000 miles.

It is true that as we extend to the ports on our eastern coast this difference becomes comparatively less, and when we consider foreign

ports it adds but a few miles to their voyage, whether Nicarauga or Panama be the point of transit. The former route would lessen their distance to our Pacific coast, and increase it for the western coast of South America. But the margin of difference is small for foreign commerce by the adoption of either of the more northerly routes than Panama, and the difference to foreign commerce between adopting Nicaragua or Tehuantepec, on the score of distance solely, is insignificant, while to us in competition with foreign commerce it may be vital, as is shown by the tables of distances already noted.

Thus we see that *all* the advantages exhibited in these tables of distances, and the arguments based upon them in favor of the Tehuantepec over the Panama route, differ in *degree* only, and not in kind, when applied to the Nicaragua transit, which latter, in its inception and nature is *foreign*, debouching into the Carribean Sea, the command of which will be beyond our control, instead of into the Gulf of Mexico, which, in common with Mexico, we may call our own sea.

We come now to local considerations of the rival routes of Nicaragua and Tehuantepec. As the highest order of tactical skill will not compensate for defective strategy in influencing the results of a military campaign, so the ablest efforts of constructive engineering, and even a certain amount of local facility, will not compensate for errors in the selection of the locality of the work, if of national importance; or, in other words, the advantages to be anticipated from a comparatively cheap canal will be lost to commerce if it be built in the wrong place.

It will be expected that some comparison be instituted between the commercial values of the two routes by way of Tehuantepec and by way of Nicaragua, although, as we have seen, we consider the question to be entirely independent of the relative cost of the two routes; but if either of them be hampered by natural obstacles, which cannot be overcome save by anticipating improvements yet to be effected in the mechanic arts, and so far problematical in their results, these obstacles should be fairly stated, and due weight given to them, in view of the great interests at stake in the selection of the proper inter-oceanic water-way, which shall best subserve the interests of American commerce.

From such data as we now possess, it would appear that the difference in the first cost of these two routes is not sufficiently great to make that the controlling element in the comparison of these respective routes, even supposing that they were otherwise on an equality; but as Rear-

Admiral Ammen has, in his letter of date January 23, 1880, stated that there were but two routes worth looking at, viz., Panama and Nicaragua, and deprecates the agitation of the claims of the Tehuantepec route at this time, as the latter route, he declares "is simply impossible of execution by reason of physical ob tacles," and that "the object could not be to hope to make a canal there, but simply to prevent its execution elsewhere," I feel constrained to refer to the respective estimates of the two routes, and show Admiral Ammen's method of estimating the cost of ship canals.

To exhibit the overwhelming difficulties in the way of the construction of the Tehuantepec canal, Admiral Ammen makes an estimate of its cost by taking the items of the Nicaragua canal estimate of Mr. Menocal and applying them to the Tehuantepec route as he understands it, and by such process reaches the sum of $130 000 000 as the cost of the latter canal, and then says that, when on a commission appointed by the President of the United States, in 1872, to examine and report upon the cost of the Nicaragua Ship Canal, he determined that the estimate of Mr. Menocal for that work submitted to him was too low, and in his opinion should be *doubled*, thus increasing it from $52 000 000 to $100-000 000, "therefore he should double the result of his estimate, as shown above, for the Tehuantepec Canal," and adds, "that there is greater reason for thus doubling it than existed in the case of the Nicaragua Canal estimates," and in consequence he declares that the Tehuantepec Ship Canal will cost $260 000 000! and with an inadequate water supply in the dry season.

As to the sufficiency of water, we have ample evidence, from the report of Commander Shufeldt, and with reference to the detail of Mr. Menocal's estimate of work required at Nicaragua, whether properly applicable to the Tehuantepec line or not, we cannot but think, from the obvious care used in its preparation, that it should be accepted as the standard for the location for which it was designed; but it does not profess to give more than the cash value of the work to be done, without taking into consideration the financial difficulties attending the raising the requisite funds. When the cost of the Suez Canal had reached $70 000 000 (fifteen millions of this is embraced in the item of "financial management," interest on stock and bonds, etc.), we may fairly suppose, that taking Mr. Menocal's estimate of $65 722 000 (which does not embrace any interest account) an additional item of $15 000 000 at

least on this account might properly be added to cover the entire cost of the work. Had Admiral Ammen confined himself to this, or some such modification of Mr. Menocal's estimate, his statement would have been entitled to attention which it cannot now command.

We propose to accept Mr. Menocal's estimate of $65 722 000 as covering the cost of construction, irrespective of the additional amount which financial considerations might render necessary, and which we may suppose would be encountered proportionally by any enterprise requiring promptly such large sums of money.

Mr. Menocal's estimate is:

181½ miles of canal, slack water and lake	$47 417 000
Harbor of Brito	2 338 000
Harbor of Greytown	2 823 000
	$52 578 000
Contingencies, 25 per cent	13 144 000
	$65 722 000

One word as to the harbors, before proceeding to the Tehuantepec estimates.

Greytown harbor is liable to being closed by shifting sand-bars. Did the San Juan River, with its full volume, reach the sea at Greytown, its current could be so controlled as to preserve a free channel against the littoral current of the coast, but $\frac{2}{10}$ of its volume is drawn off into the Colorado, or rather forms the Colorado, some fifteen miles above Greytown, which, running through the territories of Costa Rica, could not be diverted into the San Juan River unless by treaty stipulations, which it would be difficult, if not impossible, to obtain—so that maintaining a ship channel harbor at Greytown would be attended with very great expense.

As to Brito, on the Pacific, I know nothing but that it is now a mere open roadstead, and Mr. Menocal himself says: "At Brito, a breakwater, a pier, and dredging will be required to build a harbor large enough to secure a smooth entrance to the canal, and accommodate a *number* of vessels. *With the lake, only* 16 *miles* from the sea by the canal, possessing all the advantages of an excellent internal harbor, capable of accommodating all the fleets of the world, the harbor of Brito *need not be large.*"

This indicates pretty clearly what it now is, and what it is proposed to make it. Neither of these harbors can be improved but by an enormous expenditure and a large annual outlay for maintenance.

As less known to you, I must explain more fully the location of the Tehuantepec Isthmus, which is the narrow land between Southern Mexico and her easterly province of Yucatan, and from the shores of the Gulf of Mexico to the Pacific Ocean is 135 miles directly north and south.

The range of the Cordilleras here, as elsewhere in Central America, bears nearer the Pacific coast, leaving a plain of some 20 or 30 miles in width from the foot of the hills to the ocean, and on the Gulf side a much more gradual slope of twice that distance. The mountain peaks of from 4 to 7 thousand feet in height, fall away on either side, leaving a comparatively low pass through the high land, with a tolerably flat summit or plain, which is occupied from the summits on the east and west, each way, by streams of considerable magnitude, feeding rivers which empty into the Gulf on one side and into the Pacific on the other. On the Pacific side two or three large lagoons set up from the ocean, grouped together and in communication with each other; their extreme length some 30 miles, and breadth 15 miles. Into these lagoons several of the large rivers empty their waters, having a communication with the Pacific by an opening called the Bocobaca. These lagoons are shallow in many directions, but the bottom of silt and sand is easily excavated, and the railway company, to be spoken of presently, I am informed, design to make use of these lagoons for harbor purposes, with deep water and protected opening into the ocean.

On the Atlantic slope, the river Coatzacoalcos, with large affluents, empties into the Gulf of Mexico. This river has a bar at its mouth with 18 feet of water at low tide, very permanent, neither having shifted nor lessened in depth since the time of Cortez, and when a passage is once opened through, can be kept open at a very trifling cost. The river is of good width, one-half to one-quarter of a mile, with gentle current, and passing the bar a depth of 5 or 6 fathoms is had, and 30 feet of water can be carried for 20 miles and 26 feet of water for a distance of 35 miles from the bar; soft bottom. From this point the Island of Tacamichapa, formed by two branches of the Coatzacoalcos uniting, to the mouth of the river Malatengo, a slack-water navigation, with locks and dams, can be had, according to M. Moro's views—mostly

clay and gravel excavation. From this point, the mouth of the Malatengo, 28 miles of canal will reach the summit plains of Tarifa; at a level of about 650 feet, where a feeder of some 26 miles in length, from the Sierra at the east, will supply water to the extent of 2 000 cubic feet per second at the dryest season. From thence, the canal will descend for 23 miles to the lagoons on the Pacific, which will constitute the termination on the western coast. The 650 feet of elevation will require, at 12 and 10 feet lifts, 55 locks from the summit on each side; perhaps a few more may become necessary, as further examination may determine.

Every material needed in construction is found on the Isthmus in profusion, with a climate of uncommon salubrity, and a prolific soil. The forests abound in inexhaustable quantities of the most valuable timber—timber which resists most wonderfully the ravages of time and the elements, and resists the attacks of insects beyond anything grown in these northern latitudes, as existing structures of almost fabulous duration attest. Amongst others the *quo pague* has a reputation in this respect which has led to its extensive use elsewhere for railroad ties—and this brings me to a point made in the report of the Commission of Engineers, referred to as having visited the European works in 1871, in the interest of the projection of the ship canal here, under the Le Sere grant, and recommended the construction of the Tehuantepec Ship Canal. They say, in quoting from a foreign writer on this subject, M. de Gamond, "that it would be an error to think we can in this enterprise copy works executed in Europe under the formal rules of construction there adhered to. It is necessary, above all things, for the accomplishment of such an enterprise, to lay under contribution the immense local resources of nature, and to utilize in the employment of these resources that which is most applicable in the distinctive genius of every nation." The immense forests of the most valuable and durable timber, which lie along the route, should provide the material for locks and aqueducts, by which the expense of these otherwise most costly structures will be reduced to a fraction of that which masonry would require. We need not refer to the use of timber in the United States for preliminary works. To adopt its use at Tehuantepec is but to adopt the principle of M. Gamond, and to apply the distinctive genius of American construction to an American work, and at the same time utilize the immense constructive resources offered us in the forests of Tehuantepec.

The present transition state of ocean navigation, in which a substitution of steam for sails, and of steam vessels of enormous length for existing models, furnishes an independent and an adequate motive for the use of timber combined with stone for locks. While it would be imprudent to hamper navigation by "monumental" constructions of dimensions which might prove inadequate in the future, it would certainly be premature to build, in masonry, locks of the enormous dimensions that some ship-builders anticipate our steamships are destined to attain.

I would propose, that until experience had pointed out more clearly the requisite dimensions for ship canal locks, that they be built of the durable timber of the Isthmus, which will prove more serviceable than would locks entirely of masonry.

An American company with a grant for a railroad from the Government of Mexico, is now engaged in constructing a railroad across this Isthmus. The line of road does not encroach upon the ground possible for a canal, while it is sufficiently near to make the transportation of laborers and materials a large element of economy in its cost and management. This railway company, under the terms of their grant from the Government, are required to construct the harbors at either termini, on the Pacific and on the Gulf, with a depth of 28 feet of water, suitable to the requirements of modern commerce, which it will be to their interest to accomplish to the extent of exceeding in convenience any harbors now existing on either coast. On the Gulf, nothing more is needed to make a harbor in capacity and safety equal to any in the world than to open a proper channel for a few hundred yards (800) through a permanent bar, and on the Pacific, the same facility is anticipated in utilizing the upper lagoon.

Mr. Wm. J. McAlpine, is Consulting Engineer of this company, and this will be a guarantee that what they undertake in hydraulic works will be thoroughly accomplished. Their Chief Engineer, Mr. Van Brocklin, is also a member of this Society. Both of these gentlemen are now there, and as the work progresses, data for the proper determination of the canal location will be developed, and it could not be in better hands.

The present company have not a concession from the Government for the construction of a canal, but only the railway, which, when constructed, will insure the carrying out of the ship canal project, in the most economical manner possible.

We are not in possession of the data desirable from a location survey and profile for a canal on this Isthmus. M. Moro, with full means in his possession for the prosecution of his enquiries, spent nine months on the Isthmus, having in view solely the construction of a ship canal, and could see no reason whatever, either from climate, or facilities for supplies, both of material and labor, why the work should cost more than similar work in Europe. To be sure (this was in 1842) the dimensions of ships had not reached the point to which they have since progressed, and he assumed for a ship canal, the model of the Caledonian canal in Scotland, width of top water 120 feet, bottom 50 feet, and depth 20 feet—a very respectable canal even now—but his locks were restricted to the commerce of the day, as seen in that canal—length 180 feet, and breadth 40 feet, with 8 feet lifts. On this basis, with a thorough knowledge of all the difficulties to be encountered, including expensive feeders with tunnels, he estimated the cost of the entire work at $17 000 000, building materials, stone, lime, &c., abounding in the locality.

Without intending any disparagement to the labors of Prof. Fuertes, whose report in connection with this work exhibits great ability, I quote from M. Moro the level of the summit pass at Tarifa as 200 metres (656′). The lowest level given by Mr. Fuertes is 707 feet. The latter engineer gives a profile of the feeder some 27 miles in length, on which there are several tunnels, but this is not intended for navigation. And to do away with the prejudice which a paper read before the Geographical Society would give rise to, I beg leave to state that no tunnel for the navigable canal is contemplated on the Tehuantepec Isthmus. The precise depth of the summit cut I am unable to state, but it need not be greater than many railroad cuts in this country, and comparatively for a limited distance, and while it is probable that some rock may be encountered, appearances indicate that most of the excavations will be in less formidable material. From the best data in my possession, I beg leave to propose the following, as in my judgment ample for the construction of this canal, taking the same cross dimensions of canal and locks as were assumed by Mr. Menocal at Nicaragua, viz: canal $\frac{150}{84}$—22 feet depth; locks, 400′×60′; 10′ and 12′ lift; but the latter, combined locks of timber and stone, and no harbors estimated for, as the existing grant to the railway company provides for these:

From the Gulf of Mexico to Island of Tacamichapa, on Coatzacoalcos River	40 miles.
Canal to Malatengo River	54 "
Canal up Chichihua River to Tarifa	25 "
From Tarifa to Upper Lagoon	26 "
By way of railway company's works through the lagoon to Pacific Ocean	15 "
Total distance	160 miles.
or to construct by the canal company	40 miles river, 105 " canal.
Total	145 miles.

Locks, 13 of 10½ feet lift each, and 97 of 12 feet lift—total, 110 locks, 650 feet:

110 locks at $100 000	$11 000 000
105 miles canal at $300 000	31 500 000
27 miles feeder, $200 000	5 400 000
Contingencies, 20 per cent	9 600 000
	$57 500 000

We believe that the Coatzacoalcos River admits largely of slack-water improvement, if not to the junction of the Malatengo, certainly for many miles above the Island of Tacami chapa, and that in that event the above estimates would admit of a large reduction, but as we are putting ourselves on record in this matter, we prefer to be on the safe side. The principle of hydraulic excavation is peculiarly applicable to this work, by reason of the character of the streams emptying into the main valley and the material to be excavated and the opportunity for waste-weirs and side cuts in the improvement of the Coatzacoalcos (not being inclosed in a narrow ravine), all point to an economical result.

Nor is a lock of these dimensions, built of timber, an experiment. A graving dock has been in successful operation for several years in Brooklyn, at the Erie Basin, built of Southern pine, 500 feet in length, 60 feet in breadth, and with 22 feet water, and is considered as preferable to a stone dock in every respect, and at a cost which justifies my estimate above of $100 000 per lock.

If a proper system of fenders and posts is provided, and a sufficient number of filling culverts properly spaced in the locks, particularly if the latter be of timber, I can see no reason whatever to apprehend any liability to accident. With ordinary care a ship may pass such a lock without marring the paint of her bends—and within twenty minutes of time.

There remains to compare the respective times of transit:

Tehuantepec Isthmus—

40 miles of open river, at 10 miles per hour.....	4 hours.
105 miles canal, at 4 miles per hour.....	26 "
110 locks at 20 minutes.....	37 "
	67 hours.
Estimate of Mr. Menocal for Nicaragua.....	38½ "
Difference of time in favor of Nicaragua.....	28½ "

Whatever may be the advantage in point of time of a transit at Panama over that at Nicaragua, as we are dealing with the latter entirely in this comparison, we have to state that the passage of the Tehuantepec Canal will require one day more than the canal at Nicaragua, or, at the outside, two days. As regards the objections to locks—whatever route be adopted, even the through cut, so called, if it can be built, will require a tide-lock, at least, on the Pacific. In admitting that mean tide on either side would be at the same time the rise on one side of 20 odd feet, and on the other of 1½ feet, would require a tide-lock for adjustment of current. The fact that the Red Sea level was *traditionally* some 30 feet above the Mediteranean, and results demonstrated in a canal of 90 miles in length, connecting the two, that the difference was really inappreciable, has no bearing whatever upon this question.

The route which, as we have seen, while giving all proper facility to European commerce through American water-ways, still from its geographical position gives a proper preponderance to our domestic commerce, requires the use of lift-locks. Shall 24 or 48 hours additional time for its passage, and the bugbear of the danger of such transit, which differs but in degree, and not in kind, from the most favorable route which European interests can point out, deter American enterprise from carrying out what the interests of her growing domestic commerce calls for, and leave her to gather such crumbs as older nations have determined shall be her share?

Public opinion is beginning to express itself, in a manner not to be mistaken, adverse to any foreign occupancy among the small States of Central America, where a question of the infringement of the rights of such occupants by the local government could so easily be made the pretext for the interference of a foreign power, ostensibly for the protection of the rights of its own citizens, but virtually to deprive this Government of the control of her own domestic trade. This feeling has been aroused by the late movements of a French company at Panama. But, indeed, either at Panama or at Nicaragua, if a ship canal should be built under circumstances of control nominally favorable to this country, and in accord with the spirit of the Monroe doctrine, as we construe it, yet its location, although endorsed by high officials, would, as we have seen, be so much more favorable to foreign than to American commerce that the legitimate growth of the latter would be completely crippled; and to prevent such a consummation we must go still further, and refuse countenance or support, in any way, to the construction of a ship canal located at any point south of the Peninsula of Yucatan; or, in other words, south of the Isthmus of Tehuantepec. And the importance of enlightening our people as to the national bearing of this question of the location of a ship canal cannot be overestimated. It is no longer *who* shall build it, nor *how*, but *where* it shall be built, that interests us as American citizens.

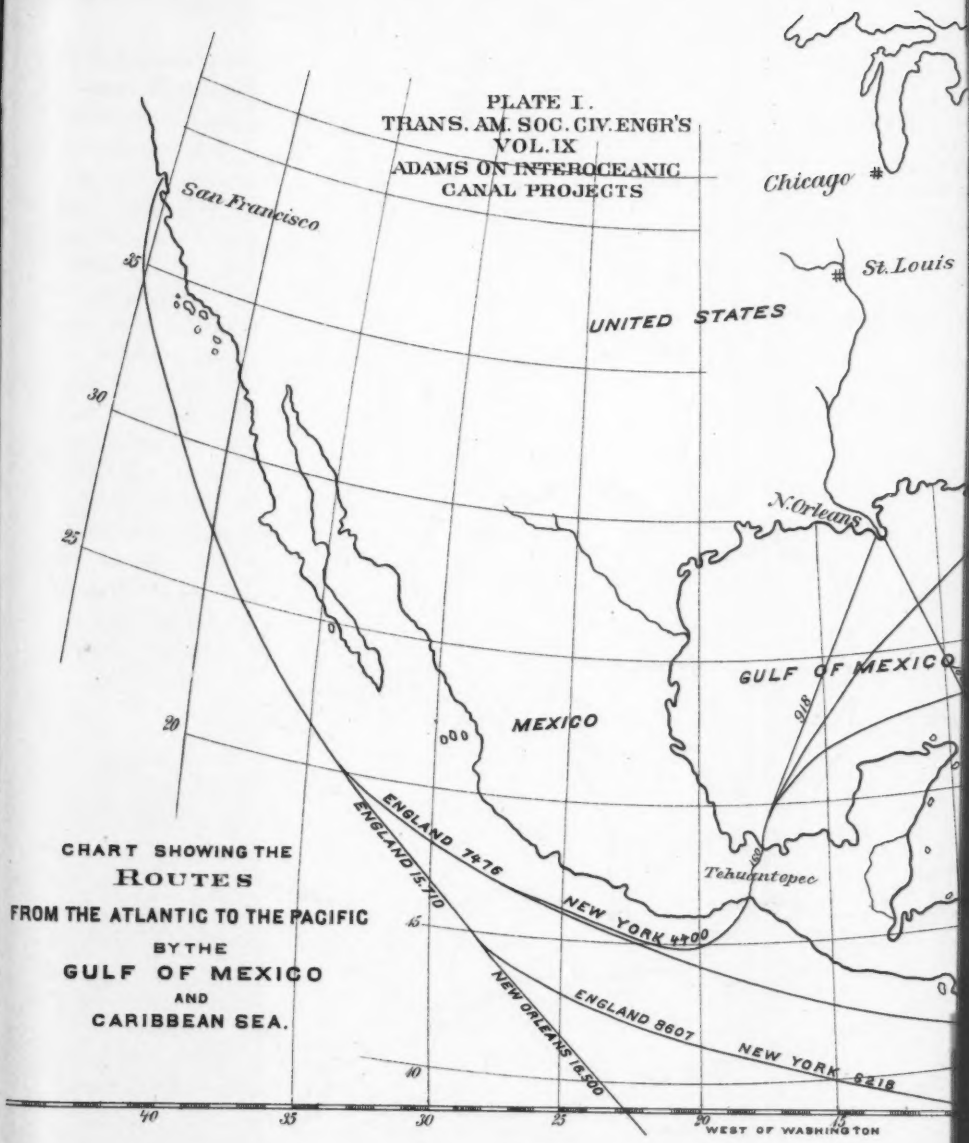
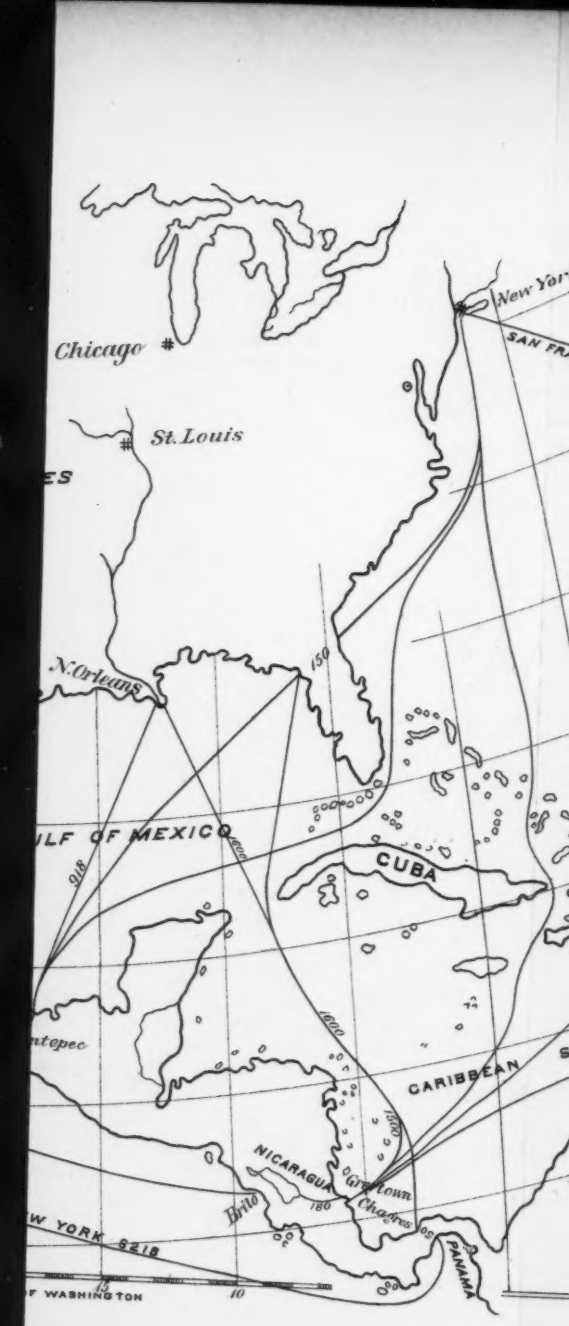


CHART SHOWING THE
ROUTES
FROM THE ATLANTIC TO THE PACIFIC
BY THE
GULF OF MEXICO
AND
CARIBBEAN SEA.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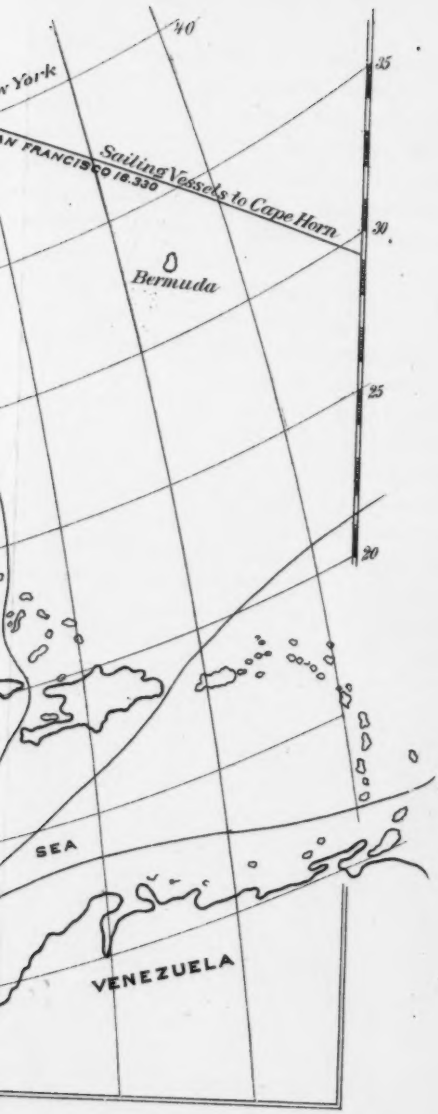
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